

Exam Format: *Similar to Mid-Term.*

Part 1 - Lecture Exam: closed book exam, short answer, essay, terms, definitions (make sure you know how to sketch relationships).

Part 2 - Lab Exam: Equation lists, conversion charts, and calculators accessible (but not entire note books). Suggestion, organize diagrams and equation lists by topic, so that you can easily find and use your tools on the open-book portion of the exam.

Recommended Study Techniques:

Memorize / study key words and concepts from class notes (focus on yellow highlight words below)

Review/watch class video resources (Youtube resources on drilling, well installation, aquifer testing)

Complete all lab exercises / review answer keys before exam

Read over textbook chapters on Moodle Class Site

## KEY TERMS AND CONCEPTS

### *Gordon Grant / Science*

#### *Pub/Water in the West*

[http://www.wou.edu/las/physci/taylor/es476\\_hydro/ES476\\_Science\\_Pub\\_Summary\\_Notes\\_Feb\\_8\\_2016.pdf](http://www.wou.edu/las/physci/taylor/es476_hydro/ES476_Science_Pub_Summary_Notes_Feb_8_2016.pdf)

Hydrologic Cycle

Climate Change

Water Resources:

Quantity

Quality

purpose

Rainfall patterns western U.S.

Willamette Valley Landuse:

5% urban,

20% agriculture,

70% forestry

“Water year” = Oct 1 to Sept 30

Willamette 2100 Climate:

warming average

monthly and annual

temperatures,

receding snow pack to

higher elevation peaks

in Cascades

Western Cascades and Coast

Range = old, lower permeability rocks

High Cascades = younger, higher permeability volcanic rocks

“High Cascade Aquifer system”

Groundwater dominated basins include Clackamas, Mckenzie, Santiam;

Western Cascades and Coast Range basins are more flashy and seasonal in discharge

Climate Models:

climate

Drainage Efficiency:

Vegetation

Water Policy

rain vs. snow,

temperature

timing of precipitation,

total precipitation,

vegetative growth

cycles vs. seasonal precipitation patterns,

snow/rain mix according to elevation

Future Policy: increase dams, interbasin transfers, forest management, economic/social shifts in population

*Hydrogeologic Setting of*

*Willamette Valley*

[http://www.wou.edu/las/physci/taylor/es476\\_hydro/willamette\\_valley\\_hydro.ppt](http://www.wou.edu/las/physci/taylor/es476_hydro/willamette_valley_hydro.ppt)

[http://www.wou.edu/las/physci/taylor/es476\\_hydro/Gonthier\\_1983\\_Groundwater\\_Monmouth\\_Dallas\\_excerpt.pdf](http://www.wou.edu/las/physci/taylor/es476_hydro/Gonthier_1983_Groundwater_Monmouth_Dallas_excerpt.pdf)

Coast Range marine volcanics and sed. Rocks

Alluvial Fill

Missoula flood deposits

Terrace gravels

Willamette alluvium

Willamette Silt

Portland Basin Gravels

Central-Southern Valley silts

Willamette Aquifer System

Basement confining unit

Columbia river basalt

Willamette confining

Willamette Aquifer

Willamette Silt

Unconsolidated valley fill

Valley-fill alluvium

Fractured basalt aquifer

Gravel aquifers

Missoula flood silt

Western Cascades Volcanics

High Cascades Volcanics

hydrogeologic setting

Quaternary alluvium

Quaternary older alluvium

Quaternary terrace deposits

Missoula Flood Deposits

Willamette Silts  
gravel aquifer  
unconfined aquifer  
regional hydraulic gradient  
Spencer Formation; Toe  
Columbia River Basalts  
Groundwater Contour Map  
salinity concentration  
gravel aquifer

### **Groundwater Key Word Search**

[http://www.wou.edu/las/physci/taylor/es476\\_hydro/groundwater\\_key\\_word\\_search\\_exercise.pdf](http://www.wou.edu/las/physci/taylor/es476_hydro/groundwater_key_word_search_exercise.pdf)

Aquifer  
Aquiclude  
Porosity  
Permeability  
Saturated vs. Partially saturated  
Aquifers  
Pore pressure  
Capillary force  
Darcy's Law  
Permeameter  
Hydraulic conductivity  
Intrinsic Permeability  
Darcy's velocity  
Isotropic vs. anisotropic  
conductivity  
Matric potential  
Vadose zone  
Infiltration capacity  
Wetting front  
Capillary fringe  
Base flow  
Confined aquifer  
Unconfined aquifer  
Unsteady vs. steady flow  
Hyporheic zone  
Effective porosity  
Yield porosity  
Macro porosity  
Saturated front  
Water table  
Potentiometric surface

### **Intro to Groundwater Notes**

[http://www.wou.edu/las/physci/taylor/es476\\_hydro/gwater1.pdf](http://www.wou.edu/las/physci/taylor/es476_hydro/gwater1.pdf)

Physics Review (know units  
and be able to calculate / define  
the following):

potential energy  
kinetic energy  
force  
work  
weight  
density  
specific weight  
pressure  
Groundwater  
defined  
meteoric  
connate  
juvenile  
porosity  
intergranular  
primary  
secondary  
fracture  
vesicular  
effective porosity  
hygroscopic water  
pendular water  
porosity vs. lithology / material  
specific yield  
specific retention  
hydraulic conductivity  
permeability  
Darcy's Law  
diagram darcy's law  
hydraulic gradient  
vertical conductivity  
lateral conductivity  
permeability vs. lithology /  
material  
aquifers  
recharge  
vadose zone  
phreatic zone  
water table  
groundwater flow  
cone of depression  
drawdown  
unconfined aquifer  
confined aquifer  
aquitard  
aquiclude

capillary zone  
atmospheric pressure  
potentiometric surface  
hydraulic contours  
groundwater flow directions  
upgradient  
downgradient  
transmissivity  
storativity  
specific storage  
isotropic vs. anisotropic  
Groundwater issues  
water resource  
water budget  
contamination  
pumping / recharge  
Wells  
pumping well  
injection well  
static water level  
cone of depression  
permeameter  
Darcy's Experiment  
water table  
potentiometric surface  
confined  
unconfined  
artesian  
free-flowing artesian  
groundwater map  
hydraulic gradient  
aquiclude  
aquitard  
leaky confined aquifer  
static water level  
depth to water  
water table elevation  
upgradient  
downgradient  
groundwater flow vectors  
fractured aquifer  
porous medium  
aquifer skeleton

### **Groundwater Flow**

[http://www.wou.edu/las/physci/taylor/es476\\_hydro/gwflow.pdf](http://www.wou.edu/las/physci/taylor/es476_hydro/gwflow.pdf)

Groundwater Contour Maps  
hydrostatic pressure  
atmospheric pressure  
kinetic energy  
potential energy  
fluid pressure  
groundwater flow net  
equipotential lines

**West Salem Field Trip /  
Drilling Techniques KeyWords**  
[http://www.wou.edu/las/physci/taylor/es476\\_hydro/driscoll\\_well\\_drilling.pdf](http://www.wou.edu/las/physci/taylor/es476_hydro/driscoll_well_drilling.pdf)

Hollow stem auger  
Cable tool drilling  
Air rotary drilling  
“Casing”  
“Well Screen”  
Split spoon  
Blow counts  
Shelby tube  
Grout  
Slotted screen  
Riser pipe  
Sand pack  
Tri-cone rotary bit  
Well log  
Drillers log

**Well Installation / Hydraulics**

**Notes**  
[http://www.wou.edu/las/physci/taylor/es476\\_hydro/Sterrett\\_2007\\_well\\_construction.pdf](http://www.wou.edu/las/physci/taylor/es476_hydro/Sterrett_2007_well_construction.pdf)

Total depth  
Bore-hole diameter  
Annular diameter  
SWL  
TD  
Stick-up  
Static water level  
DTW  
Depth to water  
Datum  
Hydraulic head

know what a well installation  
looks like (be able to sketch it)

hydraulic gradient

hydraulic head  
piezometer  
hydraulic gradient  
groundwater flow vectors  
Darcy's Law  
Darcy's Flux  
drill rig  
hollow stem auger  
well screen  
well riser  
well diameter  
static water level  
pumping water level  
well recovery  
drawdown  
groundwater contours  
cone of depression  
groundwater flow lines  
hydraulic conductivity  
pumping rate  
Pump Test  
Pumping Well  
Observation Well  
Cone of Depression  
Drawdown-recovery curve  
K = Hydraulic Conductivity  
T = Transmissivity  
S = storativity /  
storage coefficient

Seepage Velocity (linear  
velocity)

## Lab Skills to Focus On for Final

Can you perform simple and complex unit conversions?

Do you understand dimensional analysis and unit algebra?

Do you know how to manage positive and negative exponents with respect to unit algebra?

Can you perform the following quantitative skills from the first lab:

- plotting a graph
- re-arranging equations
- solving for unknown variables in an equation
- manipulating exponents and bases
- convert between metric and english systems of measurement

~~Ice Budget balance problems~~

~~Recurrence Interval / Flood Frequency Problems? Rational runoff hydrology problems?~~

Can you perform the following quantitative skills from the second lab:

- determine volumes of water in a reservoir
- calculating rates of discharge, evaporation and input into a hydrologic system
- converting between various measures of area, length, volume, and discharge
- determine the total input and withdrawal from a simple hydrologic system (calculating water budgets)

Can you perform the following quantitative skills from the contouring exercises

- draw contour lines on rainfall data? draw contour lines on groundwater elevation data?
- identify contour intervals and interpolate between data points

Can you perform the following quantitative skills from the intro groundwater problem set (set 1)?

- calculate: weight, force, density, specific weight as applied to water
- solve for the variables in Darcy's law
- determine hydraulic conductivity from a set of given values
- calculate transmissivity of an aquifer
- draw a groundwater contour map and draw generalized groundwater flow lines
- Can you calculate hydraulic gradient from a groundwater contour map

How about the problems from Groundwater problem set two.

Check out the answer keys and make sure you can work the problems and tutorials for the following labs:

- Groundwater Problem Set 1 (Introduction to Groundwater)
- Groundwater Problem Set 2 (Groundwater Flow)
- Groundwater contouring Exercises
- Well Log Interpretation
- Applications to Groundwater Hydraulics

Key Groundwater Equation Summary (problem focus for exam):

Work	Transmissivity
Force	Storativity
Weight	Hydraulic Gradient
Pressure	Darcy's Flux (Q)
Density	Seepage Velocity
Porosity	Well Drawdown
Permeability	Well Yield
Specific Yield	Well Specific Capacity
Specific Retention	
Darcy's Law / Permeameter Equations	

~~Stream discharge~~

~~Continuity equation~~

~~Probability/recurrence interval equations~~

~~Interpreting flood hydrographs~~

~~What is the difference between a stream rating curve and a flood frequency curve?~~